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Glycophorin A biodosimetry in Chernobyl cleanup workers from the Baltic countries

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The 1986 Chernobyl nuclear accident resulted in massive contamination of the area, necessitating evacuation of the population, extensive environmental cleanup of radioactive materials, and construction of a sarcophagus to isolate the reactor.[1] These operations were accomplished by 500 000 to 600 000 workers from all 15 republics of the former Soviet Union. To characterise the exposure to radiation and the potential adverse health outcomes in these populations, we have undertaken a comprehensive cohort study in the Baltic countries using record linkage techniques. Here we report estimates of physical doses and biodosimetry data for 782 of these workers.

Subjects, methods, and results

We identified three populations of Chernobyl workers who were male residents of Estonia (4836), Latvia (5709), and Lithuania (5446) and who were sent to the Chernobyl area primarily in 1986 or 1987. Estimates of their physical doses are based on dosimetry records obtained from Soviet military lists and individual Chernobyl passports. We derived biodosimetry data for 453 workers from Estonia (recorded physical doses: range 0.02-28.3 cGy, median 9.5 cGy, arithmetic mean (SD) 10.7 (6.4) cGy), 281 from Latvia (range 0-27.8 cGy, median 9.4 cGy, mean (SD) 9.6 (7.7) cGy), and 48 from Lithuania (range 2.5-36.0 cGy, median 16.2 cGy, mean (SD) 16.1 (7.7) cGy). Given the uncertainties of measurement and reporting surrounding these estimates, we wished to determine whether the radiation doses received by these workers resulted in a detectable biological response in an independent biodosimetric assay. We used the glycophorin A in vivo somatic cell mutation assay. This uses immunolabelling and flow cytometry to enumerate variant erythrocytes in peripheral blood expressing phenotypic loss of the glycophorin A allele resulting from mutations in the glycophorin A gene in bone marrow progenitor cells.[2] This assay has shown an association between exposure to ionising radiation and long term elevation of variants with loss of the glycophorin A allele in several populations, including those at Hiroshima, Japan,[3] Chernobyl,[4] and Goiânia, Brazil.[5]

We measured the frequency of such variants (per million erythrocytes analysed) in blood samples from the 782 workers and 60 male control subjects (27 from Estonia, 24 from Latvia, and 9 from Lithuania). These controls were from the same populations from which the cleanup workers were drawn and were group

Table 1—*Frequencies of variant erythrocytes with loss of glycophorin A allele (per million erythrocytes analysed) in blood samples from Chernobyl cleanup workers and controls from Baltic countries*

Population	No of subjects	Frequency of variants (×10⁻⁶)			P value*
		Range	Median	Mean (SD)	
Controls†	60	0.2-38.4	6.0	6.7 (5.5)	
	59‡	0.2-13.6	6.0	6.2 (3.6)	
Cleanup workers:					
Estonia	453	0.3-145.6	6.6	8.4 (9.1)	0.073
	444‡	0.3-24.6	6.6	7.6 (4.5)	0.071
Latvia	281	0.3-213.8	7.0	9.6 (14.6)	0.062
	274‡	0.3-32.0	7.0	8.0 (5.7)	0.068
Lithuania	48	2.0-96.2	6.6	9.9 (14.3)	0.11
	46‡	2.0-15.0	6.5	7.2 (3.1)	0.15
All	782	0.3-213.8	6.8	8.9 (11.7)	0.054
	762‡	0.3-25.4	6.6	7.7 (4.8)	0.062

* Mann-Whitney U test for workers *v* combined controls.
† Comprising 27 subjects from Estonia, 24 from Latvia, and 9 from Lithuania.
‡ Extreme outlier values (>3.0×distance between 25th and 75th centiles) omitted.

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matched for age. The data, summarised in table 1, show a tendency for increased frequency of variants with loss of the glycophorin A allele in all three groups of workers compared with the controls, although none of the differences is significant. The pooled results, with an average increase of frequency of ~ 1-2x10^{-6} corresponding to radiation doses of ~ 4-8 cGy,[4] indicate that these workers' average exposure was unlikely to greatly exceed 10-20 *cGy,* the approximate minimum radiation dose detectable by our assay.

Comment

We undertook this biodosimetry study to ascertain whether many Chernobyl cleanup workers received substantial radiation exposures that were either undocumented or inaccurately recorded. Our initial biodosimetry data strongly suggest that this is unlikely. It also seems that there is not a large subset of these workers who received doses substantially above the average physical doses. Thus the estimates of physical doses, while perhaps incomplete and imprecise, cannot be rejected as inadequately characterizing the workers' exposures. Our results support the use of these estimates to assess possible health hazards and as the basis of power calculations for epidemiological studies of populations of Chernobyl cleanup workers. To strengthen this conclusion, we are now performing fluorescence in situ hybridisation (FISH) based chromosomal translocation analysis in the peripheral blood lymphocytes of these workers. We are also studying the incidence of leukaemia and prevalence of thyroid cancer and are constructing assessments of exposure using combined physical dosimetry records, extensive questionnaire data, and biological dosimetry methods.

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Conflict of interest: None.

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